An Energy-Efficiency Workshop and Exposition-Orlando, Florida

Geoexchange: A Power Reduction Technology

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U.S. Environmental Protection Agency on Geoexchange:

- "The most energy efficient, environmentally clean, and cost-effective space conditioning systems available today"

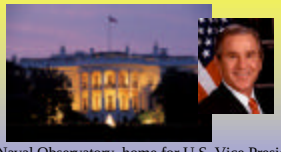
"Space Conditioning: The Next Frontier," EPA 430-R-93-004, April 1993

U.S. Department of Energy on Geoexchange:

- "No active technology for heating and cooling is more efficient than the geothermal heat pump."

- EIA, *Annual Energy Outlook 1994*, (Washington, DC, January, 1994), Table 21

GeoExchange Today in the U.S.



- President George W. Bush installed a GeoExchange System in his Texas Ranch

- Naval Observatory, home for U.S. Vice President Dick Cheney, has a GeoExchange System in the Administration Building

Geoexchange: A Power Reduction Technology

- The ability to add new supply is a major challenge for many states/utilities.
- It is easier to save a megawatt than it is to build a megawatt!
- Geoexchange is the answer!

Geoexchange: Current Market

- Currently there are approximately 750,000 geoexchange systems installed nationally. This is less than 1% of the market These account for:
  - 5,994,491.42 MWh saved annually
  - 1982.29 MW demand reduced annually
  - 1,201,017 tons carbon equivalent eliminated
  - 4,403,730 tons CO2 eliminated annually
  - 971,022 cars removed from the road
  - 288,899,215 trees planted
  - 601,873 acres of trees planted
  - 16,135,792 barrels of crude oil saved per year (that's 44,208 barrels per day)

Geoexchange: A Solution Technology

- Geoexchange is a proven technology that is here and now!
- Geoexchange is available in the marketplace today

Brief History of Heat Pumps

- Basic refrigeration cycle
- Adapted for both heating and cooling in 1930's
- Heavy use of air to air heat pumps in last 30-40 years
- Ground loop concept developed in mid 1970's
- On-going research
  - Installation techniques
  - Efficiency enhancement
  - Rock and soil conductivity studies
- Operational since the late 1970's

Terminology

- Ground Source Heat Pumps
- Ground Coupled Heat Pumps
- Ground Connected Heat Pumps
- Geothermal Heat Pumps
- Geoexchange Systems

Types of Geoexchange Systems

- Open Loop
- Closed to the Aquifer
- Standing Column Well
- Closed Loop
- Hybrid
- Water Plus System

Geoexchange Benefits

- Most energy efficient, lower energy bills
- Environmentally sensitive (cuts greenhouse gas emissions by 40%)
- Low maintenance costs
- Improved Comfort -- Individual Room Control
- No Air Quality or Fire Safety Issues
- Small Mechanical Room
- Hot Water Production Capability (Free Heating)
- Ice Melting Capabilities
- Peak Power Reduction

Myths of Geoexchange

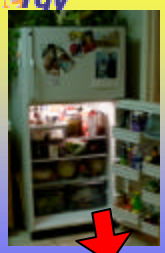
- New Technology
- Limited Geographically
- Residential Only
- Loops Fail
- Loop Maintenance
- Loop Kills Trees, etc.
- Wear the Dirt Out
- Experimental
- Too Expensive
- No Available Loop Installers
- Design Too Difficult
- Ground Overheats
- Ground Freezes
- Limited Loop Configurations

Government / Utilities
Why Geoexchange...

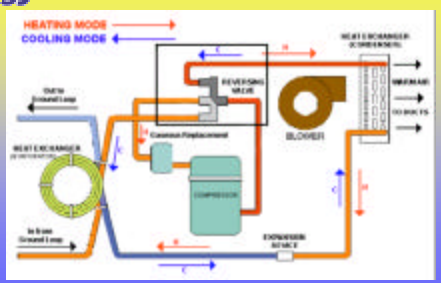
- Reduces System Peaks (0.5 kW/ton)
- Sized for building loads only (air systems increased)
- No coil losses after installation like air systems
- Reduces "heat island effect" (air systems increase it)
- Easy to shut off non-critical zones
- Saves natural gas resources, reduces emissions
- Increases market value of facility
- Maintains payback when air systems continue to lose

- Earth Absorbs 47% of Sun's Energy
- 500 times more energy than man needs annually!
- Additional energy from earth's core
- Geoexchange uses electricity to move heat to and from the earth

Like a refrigerator



Geothermal Heat Pump



Comparison

Geoexchange systems reduce noise, vandalism, leaks, & roof maintenance. Improve safety & appearances

Commercial Systems

- Extremely flexible - simultaneous heating & cooling
- Lowest life cycle cost of all systems
- Installation costs lower than most systems
- O&M costs reduced 1/2 to 1/3
- No special structures needed for conventional roof top units
- Small mechanical rooms with easy to maintain equipment
- Domestic hot water year around

Soil Characteristics

- Soil thermal characteristics are key design factors in design of the earth-exchanger.
- They are:
  - Soil porosity
  - Rock content
  - Depth and cost of trenching and drilling
  - Soil conductivity
  - Soil thermal storage capability
- In general high degree of conductivity & thermal storage perform the best.

Selecting the Team

- Mechanical Engineers with Geoexchange Experience
- Certified Geoexchange Design Professionals
- Experienced Geoexchange Contractors
  - IGSHPA Accreditation
  - Residential and/or Commercial Installations
- Geoexchange Drilling Companies

Geoexchange at 10% of Market

- If geoexchange accounted for 10% of market?!
- 12,058,252.52 MWh saved annually
  - 3,987.49 MW demand reduced annually
    - (= 13, 300 MW power plants)
  - 2,415,913 tons carbon equivalent eliminated annually
  - 1,953,265 cars removed from the road
  - 581,136,821 trees planted
  - 1,210,702 acres of trees planted
  - 8,858,347 tons CO2 eliminated annually
  - 32,458,042 barrels of crude oil saved per year (that's 88,926 barrels per day)

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Geothermal Heat Pumps in Military Applications

Since early 2000, U.S. military facilities have invested about $200 million in GHP technology

Three primary factors are motivating military facilities to convert to geothermal heat pumps

- Meet energy reduction goals
- Meet greenhous gas reduction goals
- Reduce energy costs
- Reduce maintenance costs

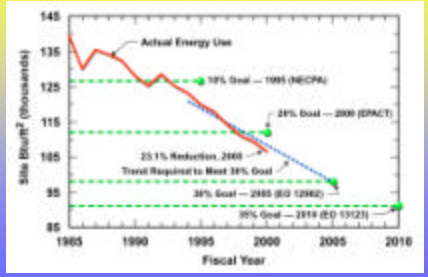
Executive Order 13123 (6/3/99) directs all federal agencies to:

- Reduce greenhouse gas emissions
- Improve energy efficiency and reduce energy consumption
- Increase the use of renewable energy

Executive Order 13123, Section 202: Energy Efficiency Improvement Goals

- Through life-cycle cost-effective measures, each agency shall reduce energy consumption per gross square foot of its facilities, excluding facilities covered in section 203 of this order, by 30 percent by 2005 and 35 percent by 2010 relative to 1985. No facilities will be exempt from these goals unless they meet new criteria for exemptions, to be issued by the Department of Energy (DOE).

Progress has been dramatic, and agencies are on track to meet



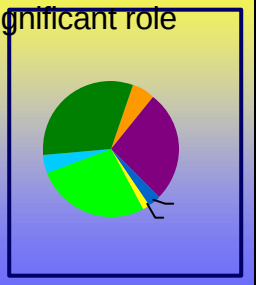
Executive Order 13123, Sec. 204: Renewable Energy

- Each agency shall strive to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable energy sources.

  The Secretary of Energy recommends that the Federal Government strive to have the equivalent of 2.5 percent of facilities' electricity consumption come from new renewable energy sources by 2005 (2.5% is about 1400 GWh).

By FY 2002 about 25% of the renewable energy goal had been met, with GHP playing a significant role

Solar Thermal	6.5	GWh
Biomass	92.5	GWh
Wind	14.1	GWh
RE Purchases/Credits	108.0	GWh
Photovoltaics (PV)	22.2	GWh
Ground Source Heat Pump	88.8	GWh
Biomass Fuels	10.4	GWh
	342.5	GWh



Executive Order 13123, Section 201: Greenhouse Gases Reduction Goal

- Through life cycle cost-effective energy measures, each agency shall reduce its greenhouse gas emissions attributed to facility energy use by 30 percent by 2010 compared to such emissions levels in 1990. In order to encourage optimal investment in energy improvements, agencies can count greenhouse gas reductions from improvements in nonfacility energy use toward this goal to the extent that these reductions are approved by the Office of Management and Budget (OMB).

These savings occur because geothermal heat pumps offer higher efficiency than air source equipment

- Can use warmer than outside air when heating is required, cooler than air when cooling
- Water-source heat pumps more efficient than air-source
  - only moving air on one side
  - refrigerant-to-water heat exchanger
- No defrost cycles (often no electrical resistance heat) at low outdoor temperatures
- Recovered heat can be put to use
- Good part load performance of entire system

Fort Polk Case Study

Scope of Ft. Polk ESPC

- Entire stock of 4,003 family housing units (1,292 individual buildings).
- Residences range in size from 1,073 to 2,746 square feet (1,393 average).
- 3,243 (or 81%) of residences were served by air-source heat pumps and electric water heaters
- Remainder (761) used gas heat with central air conditioning, and gas-fired water heaters.
- Cooling dominated climate with average 1900 HDD, 2440 CDD (base 65).

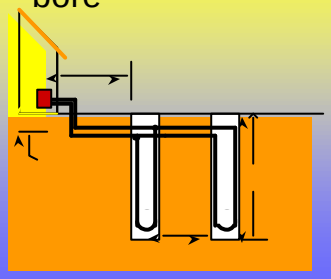
Energy Conservation Retrofits

- Air-source heat pumps and gas/central air systems replaced with GHP in all residences.
- Gas-fired water heaters replaced with electric resistance.
- GHPs included desuperheaters to supplement water heating in 75% of residences.
- Interior/exterior lighting replaced with compact fluorescent lights; some fixtures delamped.
- Low-flow shower heads.
- Attic insulation upgraded as needed in upstairs residences.

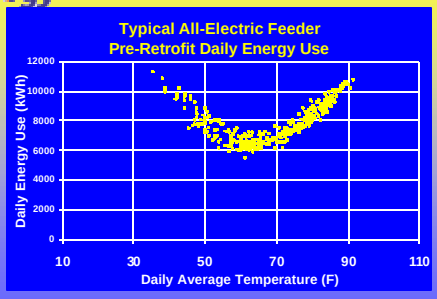
Geothermal Heat Pumps

- Total of 6,600 tons of GHP capacity installed in nominal capacities of 1.5, 2, and 2.5 tons.
- Each with its own vertical u-tube type ground heat exchanger with one circuit per bore and two circuits in parallel.
- Average 275 feet of bore per ton.
- Total of 3,621,256 feet of 1-inch SRD 11 high density polyethylene pipe installed at site.
- Bores backfilled with standard bentonite grout with no thermal enhancement.

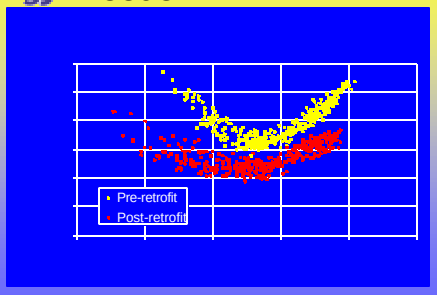
All systems are vertical bore

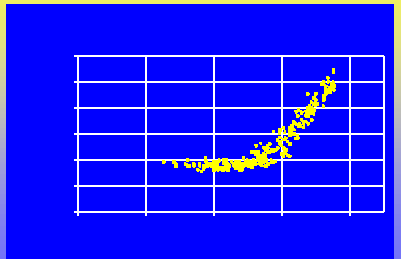


Pre-retrofit electrical use for all-electric feeder

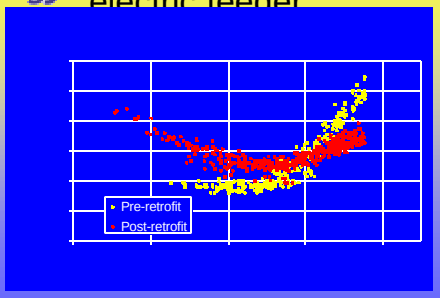


Pre- and post-retrofit energy use for all-electric feeder





Pre- and post-retrofit electrical use for gas-electric feeder



Summary of savings achieved at Fort Polk

- Electrical energy savings 25.6 million kWh, or 32.4% of annual pre-retrofit electrical energy in a typical year.
- Electrical demand reduction estimated at 6.7 MW, or 40.2% of pre-retrofit demand for peak cooling day during utility peak hour.
- Annual natural gas savings estimated at 260,000 therms.
- As a result of the ESPC, family housing at Ft. Polk is exceeding Federal mandates which direct facilities to reduce energy consumption by 30% over 1985 energy use.

Camp Lejeune: 33% energy savings

Beaufort Marine Corps Air Station: 27% savings

Other advantages of geothermal heat pumps

- Reduced maintenance costs
  - No outdoor equipment
- Increased occupant comfort
  - More stable capacity
  - Better moisture control
- Recognition
  - First LEED silver building uses geothermal heat pumps

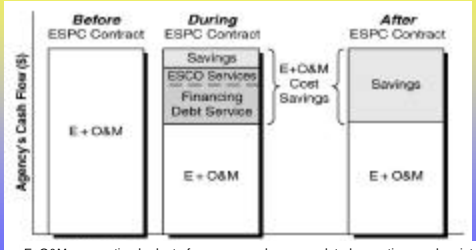
Air source heat pumps have outdoor units subject to corrosion

With a GHP, all equipment is inside the residence

GHP systems are paying for themselves

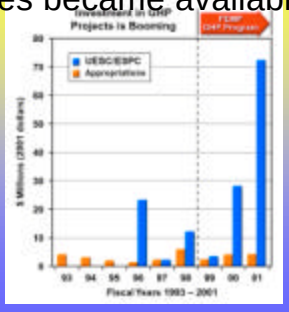
- Private capital is financing the majority of new projects (ESPC and UESC)
- ESCO or utility is paid out of energy and maintenance savings
- Simple paybacks in the range of 7 - 10 years

Structure of ESPC (UESC)



E+O&M = operating budgets for energy and energy-related operations and maintenance

Use of GHPs has skyrocketed since these alternative financing vehicles became available



Where to begin

- FEMP
  - www.eren.doe.gov/femp
- Your regional DOE representative
- Oak Ridge National Laboratory
  - www.ornl.gov/femp
- The next step depends on you